Knee Surgery, Sports Traumatology, Arthroscopy (2019) 27:2721–2730
https://doi.org/10.1007/s00167-018-4913-7

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High reported rate of return to play following bone marrow stimulation for osteochondral lesions of the talus

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Received: 13 December 2017 / Accepted: 20 March 2018 / Published online: 26 March 2018

Abstract

Purpose The purpose of this study is to systematically review the literature and to evaluate the reported rehabilitation protocols, return to play guidelines and subsequent rates and timing of return to play following bone marrow stimulation (BMS) for osteochondral lesions of the talus (OLT).

Methods MEDLINE, EMBASE and the Cochrane Library were searched according to the PRISMA guidelines in September 2017. The rate and timing of return to play was assessed. The rehabilitation protocols were recorded, including time to start range of motion, partial weight-bearing and complete weight-bearing.

Results Fifty-seven studies with 3072 ankles were included, with a mean age of 36.9 years (range 23–56.8 years), and a mean follow-up of 46.0 months (range 1.5–141 months). The mean rate of return to play was 86.8% (range 60–100%), and the mean time to return to play was 4.5 months (range 3.5–5.9 months). There was large variability in the reported rehabilitation protocols. Range of motion exercises were most often allowed to begin in the first week (46.2%), and second week postoperatively (23.1%). The most commonly reported time to start partial weight-bearing was the first week (38.8%), and the most frequently reported time of commencing full weight-bearing was 6 weeks (28.8%). Surgeons most often allowed return to play at 4 months (37.5%).

Conclusions There is a high rate of return following BMS for OLT with 86.8% and the mean time to return to play was 4.5 months. There is also a significant deficiency in reported rehabilitation protocols, and poor quality reporting in return to play criteria. Early weightbearing and early postoperative range of motion exercises appear to be advantageous in accelerated return to sports.

Level of Evidence Level IV.

Keywords Osteochondral lesions · Talus · Bone marrow stimulation · Microfracture · Rehabilitation · Return to play

Introduction

Osteochondral lesions of the talus (OLT) are a common injury in athletes and often result from acute ankle sprains or chronic ankle instability, occurring in 66% of those with chronic ankle instability and 70% of those with ankle

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00167-018-4913-7) contains supplementary material, which is available to authorized users.

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fractures [30, 31, 51]. The primary management of OLT usually consists of physical therapy and conservative management. A recent systematic review reported that conservative treatment is only successful in approximately 50% of OLT patients [75]. Surgical treatment includes bone marrow stimulation (BMS), which is typically utilized in smaller lesions less than 150mm^2, although recent studies have found clinical success is less likely in lesions greater than 107 mm^2 [58]. Arthroscopic BMS includes debridement and subsequent microfracture or drilling of the OLT defect, and typically results in good outcomes.

Several studies have demonstrated high rates of return to play sports following BMS for OLT [20, 45, 62]. However, the majority of theses studies are relatively small case series with variable rates of return, ranging from 60 to 100% [17, 20, 39, 45, 60, 62–64, 68, 69]. In addition, there is no consensus on rehabilitation protocol among studies, which may influence the clinical outcomes. Traditionally after BMS, patients have been treated with delayed weight-bearing, but recent evidence has shown that earlier weight-bearing can improve functional outcomes, and maintain functional stability and range of motion [41]. However, despite the popularity of BMS for OLT, there is still a paucity of clinical data regarding rehabilitation protocols and rate of return to play following BMS for OLT [20].

The purpose of this study is to systematically review the literature and to evaluate the reported rehabilitation protocols, return to play guidelines and subsequent rates of return to play following BMS for OLT. Our hypothesis was that there would be large variations in the reported rehabilitation protocols following BMS for OLT, but that there would be a high rate of return to play.

Materials and methods

Search strategy

A systematic review was performed by two independent reviewers according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [46]. The MEDLINE, EMBASE and The Cochrane Library databases were searched from their inception to September 8th 2017. The search strategy is in Appendix 1 in ESM. The titles and abstracts were screened using the inclusion and exclusion criteria, and full texts of potentially relevant studies were then reviewed. The references of all of the included studies were screened for additional articles that were not identified through our search strategy. Studies were included for further analysis with the agreement of both independent reviewers (EH, CM). Cases of disagreement were settled in consultation with the senior author (JK).

Inclusion and exclusion criteria

The inclusion criteria were: (1) clinical study, (2) bone marrow stimulation procedure for osteochondral lesions of the talus, (3) rehabilitation protocol or return to play data reported, (4) > 6 month follow-up if reporting on return to play, (5) published in a peer-reviewed journal, (6) written in English, and (6) full-text of studies available. The exclusion criteria were: (1) concomitant procedures/pathologies affecting rehabilitation protocols, (2) scaffold use, (3) review articles, (4) case reports, (5) technique reports, or (6) biomechanical studies.

Assessment of level and quality of evidence

All of the data were collected and evaluated by two independent investigators (EH, CM). The level of evidence (LOE) of the included studies was evaluated based on the criteria from The Oxford Centre for Evidence-based Medicine. As this a systematic review, the LOE of this study was based on the lowest level included study. The methodological quality of evidence (MQOE) was scored by two independent investigators using a Modified Coleman methodology score, which has been previously adapted for BMS for OLT [13, 58]. Studies were considered excellent quality if they scored 85–100, good quality if they scored 70–84, fair quality if they scored 55–69, and poor quality if they scored less than 55 [58]. Instances of discrepancy were resolved by consensus, and if any disagreement persisted, a senior author was consulted and a consensus was reached. The data of each study were extracted using a standardized data sheet consisting of the pre-determined list of information required.

Patient demographics

Two reviewers independently extracted the following data from each study: total number of patients, gender ratio, patient age, lesion size, and follow-up time.

Return to play and rehabilitation protocols

The rate of return to play was calculated as a percentage of patients reporting return to sport, with screening to remove any potential duplicate patients between studies. The patient reported timing of return to play was taken from studies where individual patient data was reported. In rehabilitation protocols, the earliest date for range of motion, partial weight-bearing, and full weight-bearing was recorded. The surgeon guidelines for return to play were taken from studies where the surgeon reported a time point for allowing athletes fully return to full sporting activity. The quality of each study's return to play guidelines was evaluated based on the criteria by Zaman et al. [74]. This consisted of return to play timeline, conditional criteria, measurement of conditional criteria and rehabilitation protocol (range of motion and weight-bearing timelines). A score of 4 indicated well defined return to play criteria, a score of 1–3 indicated poorly defined criteria, and a score of 0 indicated no return to play criteria [74].

Statistical analysis

All statistical analysis was performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Macintosh, Version 22.0. Armonk, NY: IBM Corp.).

Results

Eighteen hundred and twenty studies were initially identified. After removal of duplicates, 1198 studies were further analysed. After the application of inclusion/exclusion criteria, 57 studies reporting on 3072 ankles were included in the final analysis (Fig. 1).

Demographics

Fifty-seven clinical studies reporting return to play and/or rehabilitation guidelines with 3072 ankles were included (LOE I: 4, LOE II: 6, LOE III: 9, LOE IV: 38) [2–5, 7–12, 14–29, 32–43, 45, 47, 50, 52, 53, 55, 56, 59–64, 66–70, 72, 73]. There were 1858 males and 1125 females, with a mean weighted age of 36.9 years (range 23–56.8) followed up at a mean of 46.0 months (range 1.5–141). The overall MQOE was 58.4, with the majority of studies being considered "fair or poor quality". The study characteristics and patient demographics are shown in Table 1, and LOE and MQOE are shown in Table 2.

Table 1 Study characteristics and patient demographics

Studies, *n*	57
Ankles, *n*	3072
Sex, male/female, *n*	1852/1125
Age, y, weighted mean (range)	36.9 (23–56.8)
Follow-up, mo, weighted mean (range)	46.0 (1.5–141)

mo months, *n* number, *y* years

Fig. 1 PRISMA Flow Diagram

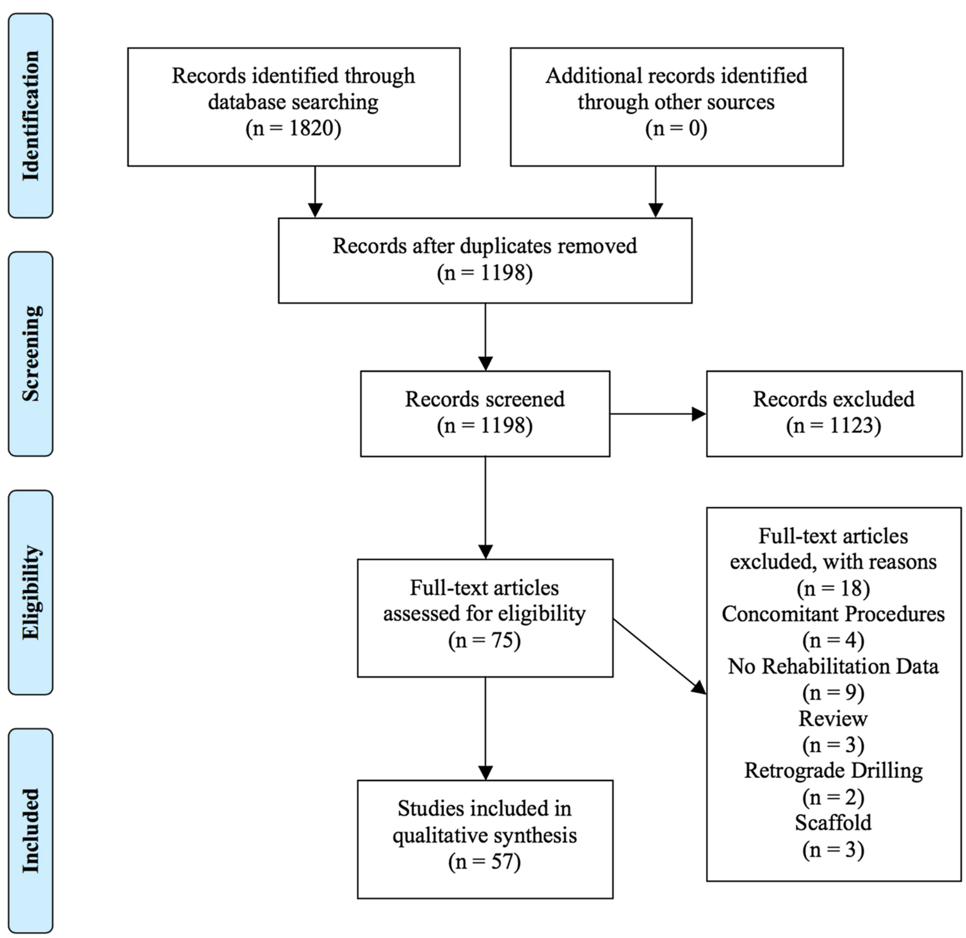

Table 2 Level and quality of evidence

LOE	
I	4 (7.0%)
II	6 (10.5%)
III	9 (15.8%)
IV	38 (66.7%)
MQOE	
Excellent (> 85)	3 (5.2%)
Good (70–84)	7 (18.9%)
Fair (55–69)	27 (47.4%)
Poor (0–54)	21 (36.8%)

LOE level of evidence, *MQOE* methodological quality of evidence

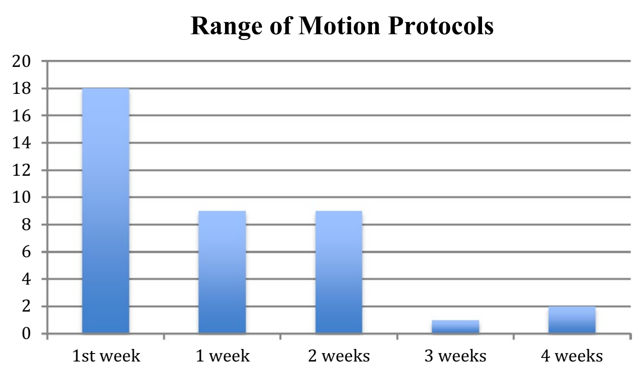

Fig. 2 Range of motion protocols

Rate and time of return to play

The summary of studies reporting return to play is shown in Fig. 2. The rate of return to play at previous levels was reported as 86.8% in 8 studies (LOE I: 1, LOE III: 1, LOE IV: 6) with 248 patients [17, 20, 39, 45, 59, 60, 62–64, 68]. The average MQOE of studies reporting return to play was 58.3. The average reported time of return to play was 4.5 months in 4 studies with 282 patients (range 3.5–5.8) [15, 45, 60, 62].

Rehabilitation protocols

Range of motion protocols

The range of motion protocol was reported in 39 studies [2, 4–9, 12, 14, 19–23, 25, 28, 29, 32–37, 40, 41, 43, 45, 47, 50, 52, 53, 55, 56, 59, 63, 66, 68, 70, 72, 73]. The most commonly reported time of commencing range of motion was within the first week (46.2%), followed by 1 week postoperatively (23.1%) and 2 weeks postoperatively (23.1%). All patients were performing range of motion exercises after 4 weeks following surgery (Table 3).

Weight-bearing protocols

The weight-bearing protocols of studies are summarized in Figs. 3, 4, 5. The time to partial weight-bearing was reported in 49 studies [2–5, 7–12, 14, 15, 17, 19–29, 32–43, 45, 47, 50, 52, 53, 56, 59, 63, 66, 67, 70, 72, 73]. The most commonly reported time of commencing partial weight-bearing was the first week (38.8%), followed by 6 week postoperatively (14.3%), and 2/3/4 weeks postoperatively (all 12.2%). The time to complete weight-bearing was reported in 52 studies [2–5, 7–12, 14, 15, 17–27, 29, 32–34, 37–43, 45, 47, 50, 52, 53, 56, 59, 63, 64, 66, 67, 70, 72, 73]. The most commonly reported time of commencing full weight-bearing was 6 weeks postoperatively (28.8%), followed by 8 weeks postoperatively (21.1%), and 2 weeks postoperatively (13.5%). The time between partial and full weight-bearing was reported in 45 studies [2–5, 7–12, 14, 15, 17, 19–27, 32–34, 37–43, 45, 47, 50, 52, 53, 56, 59, 63, 66, 67, 70, 72, 73]. No time difference between full and partial weight-bearing was most commonly reported, followed by 2 weeks difference (28.9%).

Surgeon guidelines for return to play

The surgeon guidelines for return to play were reported in 32 studies [2, 4, 9–17, 20–22, 24, 25, 27, 28, 35–37, 41–43, 45, 47, 52, 53, 60, 64, 70, 72, 73]. The most commonly reported time of surgeons allowing return to full activity was the 4 months postoperatively (46.2%), but there is variability on either side of this time point (Fig. 6).

Quality of return to play criteria

The quality of return to play criteria was poor in 51 studies and not adequately reported in 6 studies, with a mean score of 1.4 (range 0–3). The rehabilitation protocol and return to play timeline were both reported in the majority of studies, 70.2 and 56.1%, respectively. However, the conditional criteria and measurement for conditional criteria were under reported in the majority of studies, 10.5 and 0%, respectively. The individual study data for the Quality of Return to Play Criteria is in Appendix 2 in ESM.

Discussion

The most important finding in our study was that there was a high rate of return to play, 83.5%, following BMS for OLT and the mean time to return to play was 4.5 months. There is also a dearth of literature on rehabilitation and return to

Table 3 Studies reporting return to play

Author	*N*	LOE	Male	Female	Age (years)	Lesion size (cm)	Follow-up (mo)	Total rate of return to sport	Rate of return to sport (Previous Level)	Time of Return to Play (mo)
Cuttica et al. [14]	130	IV	64	66	35.1	0.9 ± 0.7	8.6	N/R	N/R	4.3
Domayer et al. [17]	14	IV	8	6	41.9	1.4 ± 0.9	55.2	85.70%	85.70%	N/R
Ferkel et al. [20]	50	IV	27	23	32	N/R	71	100%	100%	N/R
Lee et al. [39]	35	IV	27	8	35	0.9 ± 0.2	33	85.70%	62.90%	N/R
Li et al. [45]	58	IV	37	21	38.9	1.2 ± 0.4	35	100%	60%	5.8
Reilingh et al. [59]	68	I	41	27	33	< 1.5	12	N/R	84.30%	3.9
Saxena et al. [62]	26	III	18	8	36.5	N/R	32	100%	100%	3.5
Seijas et al. [64]	16	IV	15	1	24.4	N/R	43.2	93.80%	93.80%	N/R
Van Eekeren et al. [69]	93	IV	61	32	32.6	N/R	118	77.40%	N/R	N/R

N number, *LOE* level of evidence, *MQOE* methodological quality of evidence, *yrs* years, *cm* centimetres, *mo* months

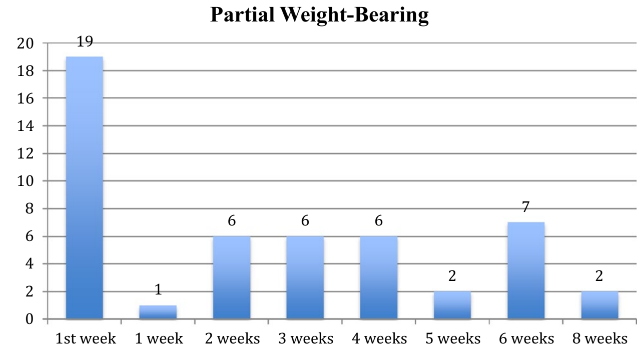

Fig. 3 Partial weight-bearing protocols

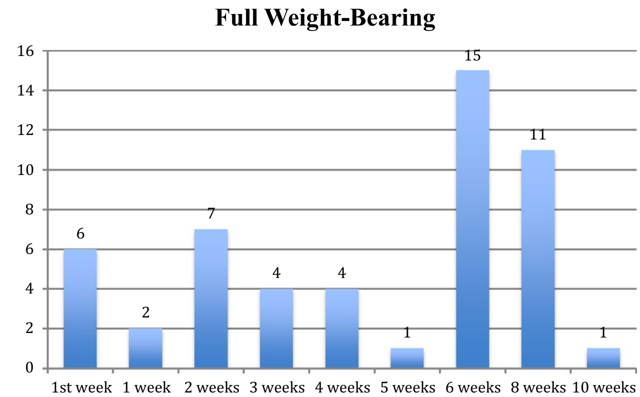

Fig. 4 Full weight-bearing protocols

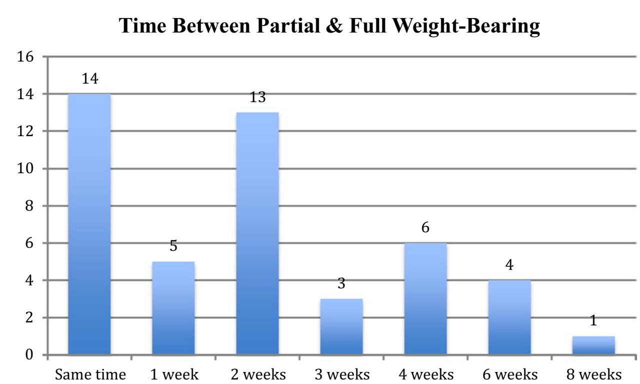

Fig. 5 Time between partial and full weight-bearing protocols

play guidelines, thus confirming our hypothesis. However, it is worth noting that the majority of these included studies were low-level evidence, which is consistent with the literature on cartilage repair in the ankle, and thus further study is needed [54].

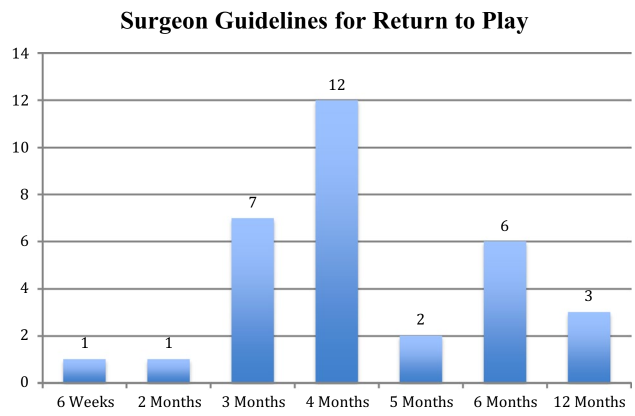

Fig. 6 Surgeon guidelines for return to play

As OLTs are a relatively common injury for athletes and often accompany ankle sprains, the rate of return to sport is an important outcome [21]. Despite the prevalence of OLT in the athletic population, the rate of return to play was reported in only 14% of the included studies. In the studies that did report the rate of return to play there was an overall high rate of return to play with 83.5%, showing that BMS is a good surgical treatment option for OLT in athletic patients [17, 20, 39, 45, 60, 62–64, 68, 69]. However, it was not possible to assess for how long patients were able to return to sporting activity before symptoms recurred, as there is little literature on long-term outcomes of BMS for OLT in athletic populations. There is evidence that longer-term outcomes of BMS are less satisfactory as the fibrous cartilage deteriorates over time and the damaged subchondral bone following BMS is not restored. In athletes, this deterioration may be accelerated as the impact from sports may further damage the cartilage and subchondral bone [20, 65]. Further studies investigating the survivorship of BMS for OLT in the athletic population are needed.

The majority of the studies allowed for the resumption of range of motion exercises of the ankle joint after the first week following BMS surgery, and 92.3% of the studies commenced range of motion exercises within 2 weeks. Earlier range of motion prevents disuse atrophy following BMS, while prolonged periods of immobilization can lead to joint stiffness due to increased scar formation and muscle atrophy [44]. Earlier mobilization has also been shown in preclinical studies to improve cartilage repair, with improved gross macroscopic appearance of articular cartilage and increased formation of hyaline repair tissue in osteochondral defect treated with BMS [61]. In animal studies, early and continuous passive motion has also been shown to improve proteoglycan and glycosaminogen synthesis in cartilage, as well as decreasing collagen breakdown [71]. However, the optimal timing to commence range of motion exercises has not been established and is necessary to further our understanding to optimally treat patients. It is unclear if there is a time point that is too early to begin range of motion exercises. In theory, earlier mobilization is advantageous due to both improved cartilage repair and decreased stiffness [61].

In the current literature there has been shown to be large variability in the timing of both partial and full weight-bearing, as well as the timing for surgeons to progress between the two. While a large proportion of studies allowed partial weight-bearing within the first week, no timing for full weight-bearing was used in more than 30% of studies. Lee et al. [41] compared the outcomes of patients with early and delayed weight-bearing after undergoing BMS for small to medium OLT. They found that both rehabilitation protocols resulted in similar functional outcomes at final follow-up, and that earlier weight-bearing did not provide any adverse risks [41]. Earlier weight-bearing also allows for patients to return to normal daily activity sooner, providing a better postoperative psychological profile, encouraging increased progressive levels of activity. However, there is a concern that earlier weight-bearing may also prevent the cartilage repair process and may even damage the repair tissue causing premature failure of the fibrocartilage milieu [48]. In addition, appropriate protocols about weight-bearing may vary slightly depending on lesion size and location [8]. Choi et al. [8] utilized different weight-bearing protocols depending on lesion size, with more aggressive timing with smaller lesions. However, no high quality studies have substantiated this protocol [8]. The current study has underscored that substantial variability exists in weight-bearing protocols following BMS in athletes, while individual characteristics of patients and patients OLTs may play a role in this variability. It does appear that overall early weight-bearing is not harmful to most patients and may help prevent overall deconditioning.

The mean time of patient reported time to play was 4.5 months (range 3.5–5.9 months), which was similar to the mean reported time of surgeon guidelines for return to play [15, 45, 60, 62]. There were large differences between studies in the surgeon guidelines for return to play, with one study allowing athletes to resume activity as tolerated after 6 weeks, while other studies allowed return when pain free but advising against any high impact activity for 12 months [4, 15, 45, 60]. While patient timing of return to play requires approximate surgeon guidelines, there should be an individualized aspect focusing on the patients themselves such as pain or muscle strength with objective criteria to determine a safe time for athletes to return [74]. Only six of the included studies reported conditional criteria, using either pain-dependent or strength-dependent parameters, but no additional measurement of these criteria was mentioned in any study [2, 4, 11, 14, 15, 73]. Furthermore, no study mentioned any radiological findings to establish if the quality of cartilage repair tissue was adequate for the athletes to return to play. Magnetic resonance imaging T2 mapping and T1-rho may be useful objective measurements to establish whether the quality of the fibrocartilage regeneration was of sufficient robustness to return to play [57].

The quality of reported return to play guidelines following BMS for OLT was poor across all of the included studies, despite OLT being a common injury in the athletes and BMS is the most common reparative procedure for OLT. The current review showed that evidence regarding a safe return to play criteria or timelines after BMS for OLT has not been established. Zaman et al. [74] had similar findings in a study on medial patello-femoral ligament reconstruction, showing no study had a method for reporting conditional criteria to return to play and recommended the development of a checklist for both rehabilitation and return to play. Objective criteria for return to play after BMS for OLT should also be developed, as it has the potential to be beneficial in increasing success rate of surgery and patient satisfaction. Radiological findings evaluating the quality of the cartilage repair tissue, patient range of motion, strength, stability, proprioception, and pain may all have an important role in deciding when an athlete is allowed to return to full athletic participation. The American Academy of Orthopaedic Surgeons released a checklist for patient specific goals which must be met to return to sport following anterior cruciate ligament reconstruction and a similar guideline may be useful following BMS for OLT [1].

Biological therapies including platelet-rich plasma and concentrated bone marrow aspirate have been suggested as a method to augment BMS procedures to improve healing and accelerate subsequent recovery times [29, 49]. However, there is no literature investigating their impact on return to play. Additionally, Reilingh et al. assessed the efficacy of pulsed electromagnetic fields and the upregulation of TGFβ on the rate of return to play [60]. However, they found that this modality did not lead to either a higher rate of return or earlier resumption of activity. Other studies have recommended cryotherapy as part of their rehabilitation protocols following BMS as this may reduce inflammation and improve the ability to return to activity at an earlier time, currently, however, there is no supporting literature for widespread use of this therapy [4]. The effectiveness of these adjunct therapies on improving return to play and rehabilitation protocols should be investigated more thoroughly in future research.

We believe the findings from this study will help guide surgeons navigate the literature on rehabilitation and return to play in the athlete following BMS for OLT. Understanding the literature will also allow for important discussion to occur when consenting a patient for BMS for OLT, and allow for surgeons to discuss expected outcomes with patients.

As this is a systematic review, there are inherent biases in the included studies that are present in this study. The majority of the included studies are retrospective in nature, are low LOE and have fair/poor MQOE [54]. Although the rate of return to play was high there were several different sports evaluated which may lead to significant heterogeneity and underreporting of data, which may prevent truly representative findings for individual sports. The overall reporting of return to play criteria was poor and needs to be standardized. The studies also included patients with concomitant procedures, mostly anterior talo-fibular ligament repair, and while we were able to screen out the studies where this affected the rehabilitation protocols, it was not possible to determine whether this affected the rate of return to play.

Conclusion

The current systematic review demonstrated that there is a high rate of return following BMS for OLT with 83.5% and the mean time to return to play was 4.5 months. It is unclear for how long athletes are able to return before the symptoms recur, as there is scant literature on long-term outcomes following BMS. There is also a deficiency in reported rehabilitation protocols, with poor quality reporting in return to play criteria and a low overall methodological quality of evidence. Thus, further research should be directed at determining the optimum rehabilitation protocols following BMS for OLT, as currently the rehabilitation protocols are based on surgeon preference rather than evidence-based medicine.

Funding No funding has been received for this study.

Compliance withethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This manuscript is a systematic review and does not contain any studies with human participants or animals performed by any of the authors.

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